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Low level laser therapy versus polarized light therapy on healing of foot burn

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***Abstract*---**Purpose: to evaluate the efficacy of the low level laser therapy (LLLT) versus polarized light therapy (BLT) on healing of foot burn. Methods of evaluation (Burn surface area and colony count). Methods: Forty patients who had partial thickness thermal burn affecting foot with the percentage of total body surface area (TBSA) ranging from 1% to 5%. Their ages were ranged from 25 to 35 years, diagnosis was clinically by physician, the patients were randomly divided into two equal groups in number; two study groups (one for LLLT and the other for BLT). The first study group (A) was composed of twenty patients who received the LLLT in addition to the traditional physical therapy routine and conservative treatment of the burn wound for one month. The second study group (B) was composed of twenty patients who received the BLT in addition to traditional physical therapy routine and conservative treatment for the burn wound. Duration of treatment was session (10 minutes) once daily, three times per week for one month or until wound healing. Results and Conclusion: Results showed that the application of both polarized light therapy and Ga-As laser had a valuable healing effect. The results of this study support the expectation that both the polarized light therapy and the Ga-As laser were effective in enhancing healing of burns, as manifested by the highly decreases BSA and CC. But

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LLLT was more effective and beneficial than the BLT in decreasing the CC indicating that LLLT was more bactericidal.

***Keywords*---**polarized light therapy, Ga-As laser, foot thermal burn, burn surface area, colony count.

Introduction

Burn is coagulative necrosis of the skin and underlying tissue. Most burns are not life threatening, but each burn causes a significant amount of pain for the patient, and some degree of psychological trauma to all those involved. At temperature greater than 120°F, it only takes 3 seconds to burn a child's skin severely enough to require surgery, [3,7,12,15,16]. Certain systemic diseases, such as injuries to the nervous system, burns, metabolism and aging, have negative influence on the healing process, and lead to chronic wound formation. Measurements show that injured tissue is characterized by higher healing potential as compared to the intact skin. The management of open skin wounds constitutes an important clinical problem, the use of electrical stimulation should be considered as a therapeutic option for treating skin wounds. Several investigators have reported a beneficial effect resulting from treatment of a variety of skin wounds with electrical stimulation, [18,19,25,27,28].

Laser is an acronym for light amplification by stimulated emission of radiation; it is a form of phototherapy which involves the application of monochromatic light over biological tissue to elicit a biomodulative effect within that tissue. Research into the role of low level laser therapy LLLT began in the late 1960s in Eastern Europe. The earliest experimental application of low power laser in medicine was reported in 1968 by Endre & Mester in Hungary who revealed that a ruby laser treatment accelerated healing of mechanical wounds and burns. Since the 60s the volume of research into LLLT has grown and has focused to assess the value of LLLT in wound repair, [1,2,5,10,13,17,21].

Low level laser light is different from natural light in that it is one precise color, it is coherent (it travels in a straight line), monochromatic (a single wavelength) and polarized (it concentrates its beam in a defined location. The Ga-As laser is pulsed wave with an average power output of 3mw and penetration depth of 10 cm as a result of its wave length which equal 904n. this laser have been most commonly used in lower doses for wound healing as they have deeper tissue penetration than the He-Ne laser. These lasers have the disadvantage that their light is invisible and therefore eye protection is required, [1, 2,10,13,17,21].

The use of light for therapeutic purposes dates back to the ancient Egyptians, Greeks and Romans. Current research into the physiological benefits of light therapy has developed an area of great interest which is the laser. Most research in the uses of laser was reported by European sources. Only during the past decade have American research workers begun to add the results of their studies. The notion that lights, in the visible and near infrared ranges, can produce photo chemical and photo biological changes that ameliorate pain and inflammation as well as promote tissue repair was first observed in the late 1960s. At this time the prevailing notion was that lasers were uniquely photo destructive, promoting attempts to develop powerful lasers that may yield military superiority. Thus, the mood was not right and neither were medical minds ready to accept the idea that a tool that can cut, vaporize, and otherwise destroy tissue could be used for beneficial purposes, [21,23,26,29,30].

Polarized light from low power lasers and non-laser devices has been used as a non-invasive therapy in the treatment of various musculoskeletal disorders, acceleration of wound healing and treatment of skin ulcers, although the polarized light is known to have numerous photo-biostimulatory effects including cell proliferation, enhanced collagen synthesis, changes to the circulatory system and anti-inflammatory actions, the precise mechanism of its action still remains unclear. The available non-laser optical devices are the Bioptron products which emit a wide beam of polarized, non-coherent, polychromatic, low energy light that contain wavelengths from the visible spectrum (480-700nm) and infrared radiation (700-3400 nm); this range provides optimal penetration and stimulation of the tissues without the risk of DNA damage, [6,8,9,14,22,24].

Bioptron light therapy device emits light that is polarized, polychromatic, non-coherent and of low energy. The light emitted has a wide range of wavelengths (480-3400 nm) and differs from laser light, which is mono-chromatic (of narrow wavelength), coherent, polarized and of high or low energy. Possible risk of burns is present with the laser therapy, while not possible with the Bioptron light therapy. User skills are essential in laser therapy, but not essential with the Bioptron light therapy. Higher costs are present with the laser therapy, but not with the Bioptron light therapy, in addition, treatment of large area is available with the Bioptron light therapy, [6,9,11,14,24].

Bioptron light therapy system emits light characterized by polarization, polychromacy, incoherency and low-energy; polarized light, its waves move (oscillate) on parallel planes. Linear polarization by reflection (the multi-layer mirror system, Brewster mirror), is very efficient and attains a polarization degree of 95%. Bioptron light therapy system encompasses the wavelength range from 480 nm to 3400 nm, this spectrum contains the visible light range and a proportion of infrared radiation (the electromagnetic spectrum of Bioptron light does not contain ultraviolet radiation). Bioptron light is incoherent or "out-of-phase" light, or in other words, the light waves are not synchronized, [9, 11,14,22,24].

Material and methods

Subjects

This study was carried out on forty patients who had partial thickness thermal burn affecting foot with the percentage of total body surface area (TBSA) ranging from 1% to 5%. They were participated in the study and recruited form OM-EL-Misrieen burn unit. Their ages were ranged from 25 to 35 years, diagnosis was clinically by physician, the patients were randomly divided into two equal groups in number; two study groups (one for LLLT and the other for BLT). The first study group (A) was composed of twenty patients who received the LLLT in addition to the traditional physical therapy routine and conservative treatment of the burn wound for one month. The second study group (B) was composed of twenty patients who received the BLT in addition to traditional physical therapy routine and conservative treatment for the burn wound for one month. Measurements were conducted before starting the treatment as a first record and at the end of the treatment as a second (final) record.

Instrumentation

In this study the measuring equipment were the Wound surface area (WSA) measurement in cm2 and the Colony count while the therapeutic equipment was the Ga-As laser Device and the Bioptron Compact III light therapy system (PAG-860), [3,6,9,10,17].

Procedures

Evaluation

Measurement procedures

Wound surface area (WSA) measurement in cm^2:

Wound surface (WAS) was calculated according to planimeter method by placing a piece of sterilized transparency film over the wound and tracing the wound perimeter on the film with fine tipped transparency marker. A separate transparency was used for each wound. The tracing is then placed over metric graph paper and the number of 1mm the tracing is counted (only full 1-millimeter squares inside the perimeter is counted and the area is converted to square centimeters). The wound area was measured before the beginning of the experiment and at the end of the of therapy ,[3, 7,12,16]. B- Colony count: Tools for taking swap: Sterile swab, media used for culture samples and gloves. These tools and equipment were used before treatment (First record) and after one month of treatment or till healing (Second record) to measure healing and colony count of the burn wound, [3,7,12,19,25].

Colony count: Semi quantitative culture of the wound surface area

A sterile cotton swab was rolled completely on the surface of the wound area. The swab material was emulsified well in a 5 ml sterile (0.9% NaCl). Three serial 1:10 dilutions of the suspension was made with 0.5ml aliquots and 4.5 ml of sterile saline per aliquot. A 0.1 ml aliquot of the original suspension and of each dilution was spread on the surface of the blood gar plate. All plates were incubated at 37C0 for 24 hours. The number of organisms per ml of the swab suspension was determined by counting the number of colonies on the plate that grew between 30 and 300 colonies. The number of colonies on the plate was calculated by multiplying the count in step 6 by the dilution factor. The count was done for each colony count separately. Gram stain and key tests including oxidase, and catalase tests as well as colony morphology was performed to preliminary identify each colony count, [3,7,12,19,25].

Treatment procedures

1. All patients in the 2 groups (A) and (B) received the same the traditional physical therapy routine and conservative treatment of the wound, same nursing care, same medications and described diet. Dressing was the same for all patient in the 2 groups were covered by sterile Vaseline gauze (Sofra-tulle dressing) as all dressing was changed once daily. Procedures of LLLT for the first study group (A): Both BLT and LLLT was applied once daily, three times per week for one month or until wound healing. In this study the treatment protocol was presented under the following: Patients were treated as inpatients, patients were given information about the measurement and treatment procedures as well as about the BLT and laser devices, before the beginning of the treatment, patients were asked to follow the surgeon and physical therapist instructions, patient were asked to avoid predisposing factors as UV rays, crowding and uncleaning places, hot and humid environment as well as smoking. Measurement procedures were applied for each patient as they were mentioned in the measurement section, before therapy all patients were given their written informed consent form for the BLT and laser treatment, eyes were protected from BLT or laser Irradiation, place the patient in suitable comfortable position, before the beginning of the treatment check the device to be sure that it is switched off, select the appropriate dose, switch the device on, after the end of the treatment switch the device off, and then cheek the treated area, duration of treatment was session (10 minutes) once daily, three times per week for one month or until wound healing, the burn wound was about 10 cm2, so each cm2 was irradiated for 90 seconds, 600 seconds as a total (about 10 minutes for each session). The probe of He-Ne laser was stabilized in horizontal alignment opposite to the patient but the beam of laser must be in perpendicular direction to the burn wound, the distance between the laser probe and the burn wound was 1mm length and according to the grid technique each cm^2 of the burn wound and each cm of the wound perimeter was subjected to 90 seconds laser irradiation for a session of 10 minutes, where wound surface area before treatment was 10 cm2 approximately, [2,10,13,17,23,26,30].
2. Steps of the BLT treatment procedures in the second study group (B): Position of the patient: Supine lying position is appropriate for the lower limb burns, wound preparation: the wound was cleaned at first by hydrogen peroxide, saline rinse and betadine. BLT device preparation: the plug of the BLT unit was inserted into the main current supply; the on/off switch was switched on. Then set the treatment parameters of BLT. BLT application: point the light beam at the area to be treated, holding the device at right angle (90°) perpendicular to the surface of the burn wound and maintaining a distance of 10 cm from the surface of the burn wound and applying the BLT for about 10 minutes, once daily, three/times per week for one month or till wound healing. Unplug the device after use and it is advisable to prolong the BLT for one or two weeks if wound closure occurred before the end of the treatment period (one month) in order to strengthen the treated area, [5,6,9,14,22,24].

Data analysis

Wound surface area and Colony count, were measured pre-treatment as a first record and after one month intervention as a second final record in both groups. Collected data were fed into computer for the statistical analysis; descriptive statistics as mean, standard deviation, minimum and maximum were calculated for each group. The t-test was done to compare the mean difference of the two groups before and after application and within each group. Alpha point of 0.05 was used as a level of significance,[4,20].

Results

As shown in table (1) and figure (1), the mean value of the burn surface area in cm^2 before treatment was (9.515 ± 0.421) in the LLLT group (Low level laser therapy group), while after treatment was (3.440 ± 0.313) cm^2. These results revealed a highly significant decrease in burn surface area in cm^2 ($P < 0.0001$). While in the BLT group (Bioptron light therapy), the mean value of the burn surface area in cm^2 before treatment was (9.510 ± 0.401) cm^2, while after treatment was (4.200 ± 0.221) cm^2. These results revealed a highly significant decrease in the burn surface area in cm^2 ($P < 0.0001$).

Table (1): Comparison of the mean values of the burn surface area in cm2 before and after treatment in the two groups

	Before treatment		After treatment		Mean difference	T-value	P-value	Level of significance
	Mean	SD	Mean	SD				
LLLT Group	9.515	0.421	3.440	0.313	6.07500	51.79	0.0001	Highly significant decrease
BLT Group	9.510	0.401	4.200	0.221	5.31000	51.86	0.0001	Highly significant decrease

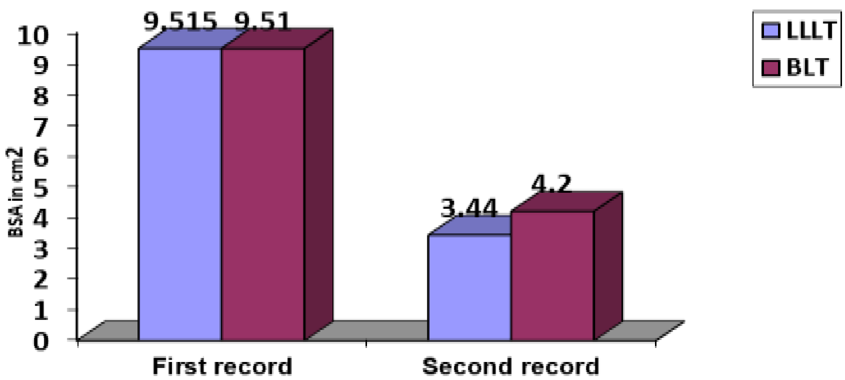

Figure 1. Bars representing the mean values of burn surface area in cm^2 of the 2 records before and after treatment in both groups

As shown in table (2) and figure (2), the mean value of the colony count in C before treatment was (25620 ± 3922) in the LLLT group, while after treatment was (244.6 ± 103.5) C. These results revealed a highly significant decrease, (P > 0.0001), while in the BLT group, the mean value of the colony count in C before treatment was (25610 ± 25700) C, but after treatment was (290.5 ± 101.2) C, these results revealed a highly significant reduction in the colony count in C (P < 0.0001).

Table (2): Comparison of the mean values of the colony count in C before and after treatment in the two groups

	Before treatment		After treatment		Mean difference	t-value	P-value	Level of significance
	Mean	SD	Mean	SD				
LLLT Group	25620	3922	244.6	103.5	25375.4	28.92	0.0001	Highly significant decrease
BLT Group	25610	25700	290.5	101.2	25319.5	4.41	0.0001	Highly significant decrease

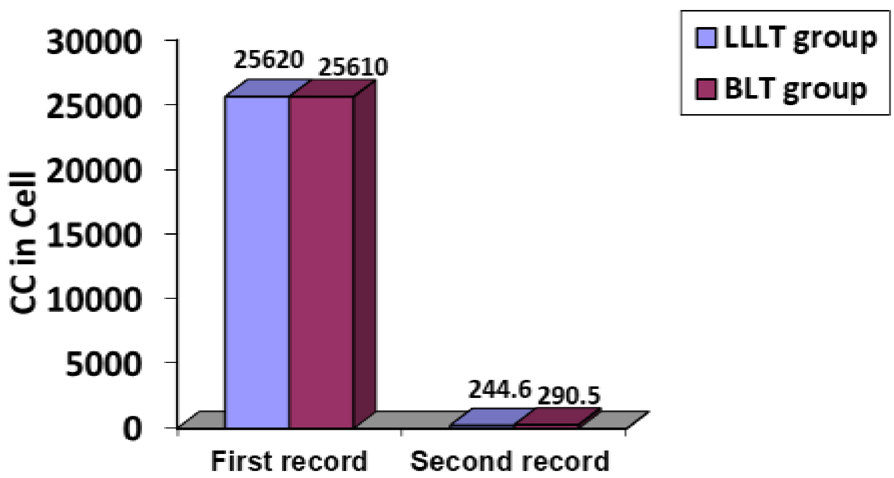

Fig (2): Mean values of the colony count in C of the 2 records in both groups.

Discussion

Burns are caused by exposure to excessive heat as flame, hot surfaces (Contact burns), scalding liquids (Scald burns), friction, electricity and chemical burns, heat destroys tissues by coagulation, thermolysis and evaporation of proteins. Exposure to irradiation may also result in skin destruction. Mild and moderate heating during the application of the therapeutic modalities will result in a reversible process, where tissues revert back to the pre-lasting temperature immediately following the application. So, this reversible heating process is valuable from the therapeutical point of view, as this process will follow the temperature law of van't Hoff, which stated that "for every rise of 10° C of the tissue, the rate of oxidation in this tissue is increased 2.5 times the normal", ,[3,7,2,15].

Dehydration following the second and third degree of burns, resulting from the increased capillary permeability with the loss of colloid, water and electrolytes, is a reversible process which can be corrected by intravenous fluid resuscitation to restore the intravascular volume and prevent the hypovolemic shock. In the other hand excessive heat burns results in the three irreversible processes, protein coagulation, thermolysis and evaporation. Protein coagulation is an irreversible process and thermolysis which is the melting process from heat still irreversible, while evaporation is the transformation of the liquid into gaseous state, this evaporation process is not easily reversed, [7, 12, 15,16].

Burns may be classified into 3 groups according to the percentage of TBSA, minor burns involve less than 10% of the TBSA, major burns involve more than 10 % of the TBSA, and dangerous burns involve more than 30 % of the TBSA the estimation of the TBSA percentage is implemented by the application of the rule of nines, which is the most common clinical method, in which the body is divided into areas, each one representing approximately 9% or 18 % of the TBSA, as follows: head and neck represent 9%, each upper limb represents 9 %, each lower limb represents 18 %, anterior trunk represents 18 %, posterior trunk represents 18 % and the perineum represents only 1%, [3,7, 12,15,16].

The basic pathophysiological consequence of the burn injury is the loss of the capillary integrity, localized increase in the micro vascular permeability, generalized impairment in the cell membrane resulting in cell swelling and increase osmotic pressure of the burned tissues leading to further fluid accumulation and oedema formation, which is a result of the outpouring of the intravascular fluid into the interstitial spaces. This process occurs at all areas of partial skin thickness burns and at the areas which are adjacent to and subjacent to the full skin thickness burns, [3, 12,9,15, 16].

Laser phototherapy uses radiation both in the visible (400 - 700 nm) and in the near-infrared (700 - 1000 nm) regions of the spectrum. When a photon is absorbed by a molecule, the electrons of that molecule are raised to a higher energy state. This excited molecule must lose its extra energy, and it can do this either by re-emitting a photon of longer wavelength (i.e., lower energy than the absorbed photon) as fluorescence or phosphorescence, or it can lose energy by giving off heat, or it can lose energy by undergoing photochemistry. Photobiological responses are the result of photochemical and/or photophysical changes produced by the absorption of non-ionizing radiation,[1,2, 10].

Bioptron light therapy system is a medical device, with expanding clinically proved efficacy both in the treatment of wounds and pain conditions as well as in the treatment of selective skin disorders, it employs a combination of infrared and visible light wavelengths considered to be beneficial in the treatment of different types of problems and injuries. Both visible and infrared light have been shown to affect different positive changes at cellular level [6,8,9,11, 14].

The findings of the present study showed that there was a highly significant decrease between the means of the second record BSA (2) (after one month of the LLLT application) and the first record BSA (1) (pre-application) (P < 0.0001).

Findings of the present study showed that there was a highly significant decrease between the means of the second record BSA (2) (after one month of the BLT application) and the first record BSA (1) (pre-application) (P < 0.0001). Findings of the present study showed that there was a highly significant decrease between the means of the second record BSA (2) (after one month of the BLT application) and the first record BSA (1) (pre-application) (P < 0.0001). The results of this study indicated that there was a highly significant decrease between the means of the second record CC (2) (after one month of the LLLT application) and the first record CC (1) (pre- treatment) (P< 0.0001).

Results of this study revealed that there was a highly significant decrease between the means of the second record CC (2) (after one month of the BLT application) and the first record CC (1) (pre- treatment) (P< 0.0001). These significant differences, between the first study group (LLLT application) and the second study group (BLT application), which were in the form of a highly significant decreases in the burn surface area (BSA) and colony count (CC), were consistent with those observed and recorded by Adam and Clark, 2006; Aplaslan and Takano, 2007; Aragona et al., 2017; Baxter et al., 2007; Begic et al., 2010; Bolton and Young, 2008; Burke-Smith et al., 2015; Calvin, 2008; Chin et al., 2015; Crouzet et al., 2015; Green and Staley, 2004; Hoeksema et al., 2009; Iordanou et al., 2007; Kono et al., 2007; Lotter et al., 2015; Medenica and Lens , 2003; Michos et al., 2016: Monstrey et al., 2008; Nussbaum, 2009; Rifai, 2010; Sattayut et al., 2008; Simic et al., 2001 and Simmons et al., 2018.

Results of this study support the expectation that application of both polarized light therapy and Ga-As laser had a valuable healing effect. The results of this study support the expectation that both the polarized light therapy and the Ga-As laser were effective in enhancing healing of burns, as manifested by the highly decreases BSA and CC. But LLLT was more effective and beneficial than the BLT in decreasing the CC indicating that LLLT was more bactericidal.

Conclusion

Application of both polarized light therapy and Ga-As laser had a valuable healing effect. The results of this study support the expectation that both the polarized light therapy and the Ga-As laser were effective in enhancing healing of burns, as manifested by the highly decreases BSA and CC. But LLLT was more effective and beneficial than the BLT in decreasing the CC indicating that LLLT was more bactericidal.

References

1. Galeckas KJ, Ross EV and Uebelhoer NS et al., (2008): A pulsed dye laser with a 10-mm beam diameter and a pigmented lesion window for purpura-free photo rejuvenation. Dermatol Surg; 34:308.

2. Gama AN, (2008): "The effect of low-level laser therapy on musculoskeletal pain: a meta- analysis." Pain; 52: 63-66.
3. Green DJ and Staley M.J, (2004): "Burn wound healing" in Richard R.L., and Staley M.J., "Burn care and Rehabilitation: Principles and Practice" F.A. Davis Co., Philadelphia. Ch. (5), PP: 70-102.
4. Hinton PR, (2004): "Statistics Explained"2nd Ed. Rutledge Taylor and Francis Group London Pp149-155.
5. Hoeksema H, Van de Sijpe K and Tondu T, et al., (2009): Accuracy of early burn depth assessment by laser Doppler imaging on different days post burn. Burns; 35:36.
6. Iordanou PA, Bellou PP and Ktenas EA, (2007): Effect of polarized light in the healing process of pressure ulcers. Int J Nurs Pract; 8; 1, 49-55
7. Kloth LC, (2005): "Electrical stimulation for wound healing: "A review of evidence from vitro studies, Animal experiments and clinical trials" Int. J. Low Extrem. Wounds Mar 4 (1): PP: 23-44.
8. Konishi N, Kawada A and Kawara S, et al., (2008): Clinical effectiveness of a novel intense pulsed light source on facial pigmentary lesions. Arch Dermatol Res; 300 Suppl 1:S65.
9. Kono T, Groff WF and Sakurai H, et al., (2007): Comparison study of intense pulsed light versus a long-pulse pulsed dye laser in the treatment of facial skin rejuvenation. Ann Plast Surg; 59:479.
10. Lotter O, Held M and Schiefer J, et al., (2015): Utilization of laser Doppler flowmetry and tissue spectrophotometry for burn depth assessment using a miniature swine model. Wound Repair Regen; 23:132.
11. Mageed SM, Ali OS and Mohamed AA et al., (2015): A Description of the Effect of Polarized Light as an Adjuvant Therapy on Wound Healing Process in Pediatrics. International Journal of Biophysics 5 (1): 18-23.
12. McGill DJ, Sørensen K and MacKay IR, et al., (2007): Assessment of burn depth: a prospective, blinded comparison of laser Doppler imaging and videomicroscopy. Burns; 33:833.
13. Meesters AA, Wind BS and Kroon MW, et al., (2011): Ablative fractional laser therapy as treatment for Becker nevus: a randomized controlled pilot study. J Am Acad Dermatol; 65:1173.
14. Michos I, Talias M and Lamnisos D et al., (2016): Tendinopathy: The Role Polarized Polychromatic Non-Coherent Light Commonly called Bioptron Light. Journal of Prevention & Infection Control 2 (11).
15. Mihara K, Nomiyama T and Masuda K, et al., (2015): Dermoscopic insight into skin microcirculation--Burn depth assessment. Burns; 41:1708.
16. Monstrey S, Hoeksema H and Verbelen J, et al., (2008): Assessment of burn depth and burn wound healing potential. Burns; 34:761.
17. Nussbaum EL, (2009): low-intensity laser therapy for benign fibrotic lumps in the breast following reduction mammaplasty. Physical therapy; 79 (7):691-698.
18. Orgill DP, (2009): Excision and skin grafting of thermal burns. N Engl J Med; 360:893.
19. Pham TN, Orgill DP and Girban, et al., (2007): Evaluation of the burn wound: Management decisions. In: Total Burn Care, 3rd edition, Herndon, D (Eds), Saunders Elsevier, Philadelphia. p.119.
20. Pipkin FB, (1984): Medical statistics made easy. Edinburgh London. Melbourne and New York.

21. Polder KD, Harrison A and Eubanks LE et al., (2011): 1,927-nm fractional thulium fiber laser for the treatment of nonfacial photodamage: a pilot study. Dermatol Surg 2011; 37:342.
22. Rifai, (2010) Bioptron? Light therapy: polarized, incoherent, polychromatic and low energy light. Positive Health (167): 1-1.
23. Sadighha A, Saatee S and Muhaghegh G et al., (2008): Efficacy and adverse effects of Q-switched ruby laser on solar lentigines: a prospective study of 91 patients with Fitzpatrick skin type II, III, and IV. Dermatol Surg; 34:1465.
24. Sattayut SA, Hughes FH and Bradley PR, (2008): Polarized light for pressure sore treatment. Laser Therapy; 11: 88-95.
25. Serrano C, Boloix-Tortosa R and Gómez-Cía T et al., (2015): Features identification for automatic burn classification. Burns 2015; 41:1883.
26. Sherling M, Friedman PM and Adrian R, et al., (2010): Consensus recommendations on the use of an erbium-doped 1,550-nm fractionated laser and its applications in dermatologic laser surgery. Dermatol Surg; 36:461.
27. Shin JY and Yi HS, (2016): Diagnostic accuracy of laser Doppler imaging in burn depth assessment: Systematic review and meta-analysis. Burns; 42:1369.
28. Simmons JD, Kahn SA and Vickers AL, et al., (2018): Early Assessment of Burn Depth with Far Infrared Time-Lapse Thermography. J Am Coll Surg; 226:687.
29. Svenda Z, Leitner C and Lazovic B et al., (2019): Complex Regional Pain Syndrome (Sudeck Atrophy) Prevention Possibility and Accelerated Recovery in Patients with Distal Radius at the Typical Site Fracture Using Polarized, Polychromatic Light Therapy. Photobiomodul Photomed Laser Surg 37(4):233-239.
30. Torbeck RL, Schilling L and Khorasani H, et al., (2019): Evolution of the Picosecond Laser: A Review of Literature. Dermatol Surg ; 45:183.